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Summer monsoon precipitation in the Himalaya reconstructed from a tree-ring network of oxygen isotope chronologies

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Though over the last couple of decades researchers have reconstructed past climate variations for the western Himalaya using tree-ring-width records, climate reconstructions for the central and eastern Himalaya are rather few, due at least partly to reduced climate sensitivity resulting from relatively abundant rainfall. Here we developed a tree-ring network across the Himalaya by measuring oxygen isotope ratios. Sampling was carried out at one site in Bhutan, three sites in Nepal, and one site in India. A total of 10-30 individual tree samples were collected at each site. Collected cores were visually cross-dated using standard methodology, resulting in the absolute assignment of calendar years to every growth ring. We selected 2-4 trees for each site for isotopic analysis. Then cellulose was extracted directly from a wood plate (transverse section) with a thickness of 1.0 mm, rather than from individual rings usually conducted in previous studies, allowing us to process thousands of rings simultaneously. Oxygen isotope ratios of tree rings were individually determined for each core over the last 50-250 years using an isotope ratio mass spectrometer.

The variations in tree-ring delta-^{18}O obtained from Bhutan are in good agreement not only among intra-species but also among three species (r=0.78-0.89, n=50). Overall, tree-ring delta-^{18}O chronologies originating from different sites across the Himalaya showed significant negative correlations with local precipitation and relative humidity in the monsoon season, indicating that spatiotemporal variations in monsoon precipitation can be reconstructed using the tree-ring network. Though correlations of tree-ring delta-^{18}O between different sites decrease with increase in distance of sampling sites, prominent drought years are recorded in all the 5 chronologies. As moisture in the Himalaya originates from the Bay of Bengal, the amount of precipitation usually decreases northwestward. Spatial patterns of precipitation recorded in tree-ring delta-^{18}O are, therefore, of great use in investigating dynamics of monsoon circulation. The first principal component calculated using all the 5 chronologies for the past 50 years accounts for 49% of the total variance, with all positive PC loadings, reflecting mean precipitation across the Himalaya. On the other hand, the 2nd PC that accounts for 22% of the total variance shows a notable west-east contrast in PC loadings, i.e., positive (negative) for western (eastern) regions. In addition, long-term variations in tree-ring delta-^{18}O chronologies over the past 200 years also show opposite phases between western and eastern regions. Although the mechanisms underlying the west-east contrast of monsoon precipitation still need to be fully analyzed, a previous study based on speleothem records from India points out that intra-seasonal variability characterized by active and break monsoon may produce a quasi west-east precipitation dipole.

Keywords: Tree ring, Oxygen isotope, The Himalaya, Monsoon